CLASSIFICATION CONFIDENTIAL CONFIDENTIAL

CENTRAL INTELLIGENCE AGENCY
INFORMATION FROM
FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT

CD NO.

50X1-HUM

| | | | |
|---|---|---|---|
| COUNTRY | USSR | DATE OF INFORMATION | 1947 |
| SUBJECT | Scientific - Electrical calculators | DATE DIST. | 23 Nov 1949 |
| HOW PUBLISHED | Monthly periodical | | |
| WHERE PUBLISHED | Moscow | NO. OF PAGES | 3 |
| DATE PUBLISHED | Apr 1947 | SUPPLEMENT TO REPORT NO. | |
| LANGUAGE | Russian | | |



THIS IS UNEVALUATED INFORMATION

SOURCE Elektrichestvo, No 4, 1947 (FDB Per Abs 6T54).

# ELECTRICAL DEVICE FOR SOLVING SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS

Prof E. A. Meyerovich Dr Mech Sci
Power Inst imeni Krzhizhanovskiy
Acad Sci USSR

/Figure is appended/

Many authors have proposed methods of constructing electrical systems for solving algebraic equations. One of the simplest systems of this type is that of H. Bode. But since the ratios of magnitudes in electric circuits satisfy the principle of reciprocity, Bode's scheme can be applied only in cases where the matrix of the coefficients is symmetrical. Other authors have avoided this difficulty by introducing transformers into their systems (R. Mallock, V. Bush) or as elements replacing transformer-amplifiers (L. I. Gutenmacher). Plans were also proposed which permitted application of iterative methods of solving equations (K. Samsonov, V. Proshko). It has been proved possible to construct an automatic device of general form for this purpose (L. I. Gutenmacher).

However, these schemes are comparatively complicated. They call attention to the possibility of producing simpler schemes.

Below we shall describe a device which permits the solution of equations of a general form. The fundamental merit of the device is its extraordinary simplicity.

M. Reck's scheme is the nearest approach to the idea of the scheme described below, but differs from it in some essential particulars.

## Description of the Device

The circuit of the device for solving a system with three equations with three unknowns is shown in the appended diagram.



CONFIDENTIAL

CLASSIFICATION CONFIDENTIAL

| STATE | X | NAVY | X | NSRB | | DISTRIBUTION | | | |
|---|---|---|---|---|---|---|---|---|---|
| ARMY | X | AIR | X | FBI | | | | | |

The relations between the electrical quantities in this circuit are expressed by $u_1g_{1k} = I_k$ ($k = 1,2,3$; summation convention) or in expanded form:

$$u_1g_{11} + u_2g_{21} + u_3g_{31} + I_1,$$
$$u_1g_{12} + u_2g_{22} + u_3g_{32} + I_2,$$
$$u_1g_{13} + u_2g_{23} + u_3g_{33} + I_3.$$

Using the conductivity $g_{ik}$ for the coefficient of the equation and the current $I_k$ for the right sides of the equations, we note immediately that the voltage $U_k$, acting on the circuit, satisfy a system of algebraic equations. Hence, the problem of solving a system of algebraic equations with the aid of the scheme in the illustration leads to determination of voltages of such value that current $I_k$ will have the assigned value in advance. With correspondingly increased numbers of elements, the scheme can be adapted to solve a system with any arbitrary number of unknown quantities.

We are not interested here in constructing a practicable layout or selecting a method of measuring the electrical magnitudes in it. The layout can be built up for an alternating current, and in that case the coefficients of the equations can also include complex values. So that the coefficients of the equations may acquire negative values, it is necessary that the sources of the current, in addition to the terminals with positive voltage values, should also be supplied with terminals with negative voltage values. In a change of voltages, the absolute values of the voltages $+u$ and $-u$ should always remain identical.

Comparing our scheme with that of Reck, we see that the latter adopted a different grouping of resistances. (When we prepared this setup, we were not aware of Reck's work. I. S. Bruk, Corresponding Member, Academy of Sciences USSR, called it to our attention. Because of the indicated essential difference between the device which we have proposed and Reck's, we considered it expedient to publish our article.) For this reason it seems necessary to take, as the sought-for unknown values, the conductivities of the circuit, which play the part of coefficients in our scheme, instead of the voltages. Hence, with Reck's device only those systems of equations can be solved in which the signs of the unknown quantities sought for are known beforehand. Compared with the scheme described above, the possibilities of applying this device are extremely limited. It is also not a very successful solution of the problem of developing a suitable method for finding the unknown quantities.

## Derivation of the Solution

Each process of the scheme corresponds to some system of equations the right side of which consists of the assigned currents $I_k$. If, in the process of solution, one of the voltages $U_k$ is regulated, then all the currents will change at the same time.

For a solution of a given system it is possible to use Seidel's plan of successive approximations, which is frequently employed by calculators. In fact, by connecting the voltage control of each of the current sources with the corresponding current $I_k$, we can alternately establish these currents at the value assigned by the equations. Seidel's method of solution means seeking the corresponding approximate value of the unknown quantity of one line of the system and simultaneously substituting this value in all the other lines. Naturally, such an order of solutions can be made automatic. Of course, when this occurs, all the shortcomings which are characteristic of Seidel's iterative process make their appearance. But in deriving a solution with the air of an experimental device similar to the one described above, the calculator is better off than in making the calculations on paper, and he will find many advantages in using such a device.

Let us now examine the defects of the proposed device. The problem of error arises in every calculating machine. The source of error may lie in inaccuracy in fixing the coefficients or in the action of individual parts of the machine itself. Besides this, when the equations are being solved experimentally, inaccuracy in measurements may also be a source of error.

Possible sources of error in the scheme under consideration are: (1) inaccuracy in establishing the coefficients; (2) a drop in the voltage on the lines; (3) inaccuracy in measurements.

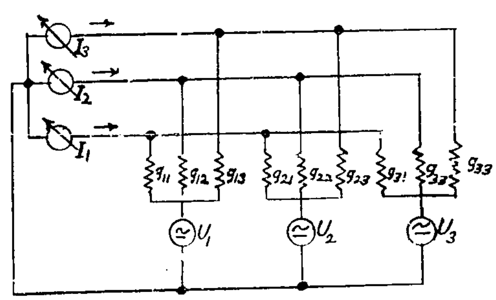
Errors in establishing the coefficients are designated by the fact that it is possible, with the conductivities, to assign a limited number of signs determined by the precision of the calibration. The use of a multidecade resistance box to set up the conductivities does not make any increase in accuracy possible due to the increase in number of decades; with a large number of decades an error in the first decade as a result of inaccuracy in the calibration may affect the other decades. This type of error occurs in nearly all electric calculating machines.

An error in the roots, regardless of the number of equations in the system to be solved, is a linear function of error in the coefficients. In the general case, the number of "true signs" for the roots depends not only on the number of true signs for the coefficients, but also upon the coefficients of the equation themselves.

In a number of problems often encountered in engineering, it is possible to put the system of equations to be solved in such a form that the number of true signs for the roots equals the number of true signs for the coefficients.

Error caused by a drop in voltage can be measured and taken into account. Error in measurements can also be reduced to a minimum in accordance with the choice of the method used. A more detailed study of error is not pertinent to the present article. Let us remark only that all the sources of error can be easily inspected and calculated.

[Appended diagram follows.]




- E N D -